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Cull-chickpea meal as a partial substitute for fishmeal in the diet of juvenile Nile tilapia (Oreochromis niloticus)

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Abstract: The inclusion of 30 and 60% of cull-chickpea meal was evaluated in formulated diets for Nile tilapia, Oreochromis niloticus, juveniles during 70 days in a closed system. The overall results indicate that the growth of tilapia fed with 30% cull-chickpea meal substitution was similar compared with the control diet (P > 0.05), thus, such an inclusion level is recommended as a dietary alternative strategy.

Keywords: agricultural by-products, alternative ingredients, aquaculture nutrition, Cicer arietinum, protein source.

1. INTRODUCTION:

Chickpea (*Cicer arietinum*) is an important protein source for human population worldwide; thus, it plays a fundamental role in food security [1]. Mexico is one of the main chickpea producers in the world and stands out for its extra-large grain size [2], an important factor in defining its final price [3]. However, part of its production results in small caliber chickpeas (approximately 10%), which is difficult to commercialize for human consumption, so in many cases, it is discarded and in others, it is sold at a low price for the manufacture of flours.

This way, cull-chickpeas should be considered a potential nutritional ingredient for aquafeeds. Fishmeal is the primary source of protein used in formulated aquaculture diets because it provides high-quality animal protein, essential fatty acids, and digestible energy; moreover, it works as a food stimulant for most species of farmed fish [4]. However, this component is increasingly expensive [5] and is nutritionally unnecessary for herbivorous fish like *Oreochromis niloticus* [6].

The Nile tilapia (*O. niloticus*) is a highly adaptable species able to grow and reproduce under a wide range of physical and environmental conditions; these characteristics have contributed to its rapid distribution throughout the world in different production systems [7]. One of the main requirements for the sustainable and successful production of this species is the provision of a low-cost balanced diet.

Over the last decade, alternative ingredients have been evaluated as replacements for fishmeal in the diet of *O. niloticus*, focusing mainly on sources of plant origin, such as legume seeds. To date, no growth studies have been conducted to assess the use of chickpea

as dietary ingredient in *O. niloticus* diets; its dietary inclusion has been evaluated in other aquatic species. For example, Reference [8] reported that the chickpea inclusion in rainbow trout (*Oncorhynchus mykiss*) diets should not exceed 30% to avoid a negative impact in its productive performance, while Reference [9] concluded that up to 35% chickpea meal can be included in the gilthead seabream (*Sparus aurata*) diet.

This study evaluated the dietary effect of two substitution levels (30 and 60%) of fishmeal for cull-chickpea meal on the growth of juveniles *O. niloticus*.

2. MATERIAL AND METHODS:

Juveniles of *O. niloticus* were obtained from the breeders kept at the Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional-Unidad Sinaloa (CIIDIR-Sinaloa) in Guasave, Sinaloa, Mexico. The specimens were fed a commercial diet until they attained adequate size for sex determination (12.00 ± 1.00 cm). Males were selected and tagged with PVC labels secured intramuscularly. For the experiment, 34 specimens per treatment were randomized in twelve 7,000 L tanks in a closed culture system. Water lost by evaporation was replaced every two days. Fish biometrics and total water exchange were performed every two weeks. The water temperature (23.7 ± 0.8 °C), dissolved oxygen (> 4 mg/L), and ammonium (< 0.1 mg/L) were recorded weekly until the end of the experiment.

Twenty-five kilograms of low-quality chickpeas (70 to 80 beans per ounce) were macerated using a coffee grinder (Grindmaster Model 500, Grindmaster-Cecilware Corp., Louisville, KY, USA), sieved to 250 μm particles, and conditioned at 23% humidity before being macerated and sieved again. The chickpea meal was introduced into 19-mm-diameter single-screw extruder (Brabender 20DN Model No. 8325, *C.W. Brabender Instruments*, Inc., South Hackensack, NJ, USA), at 127 °C temperature and 151 rpm screw speed. Subsequently, the extruded meal was cooled and dried for 24 h, to finally, be macerated and sieved again.

A control diet (35% crude protein) was formulated based on the proximal composition of the ingredients and this was used to elaborate. the experimental diets supplementing 30 and 60% of fishmeal with cull-chickpea meal (Table 1). The ingredients of each diet were mixed and homogenized in an Artisan blender (KitchenAid 325-W; Benton Harbor, MI, USA). The pellets were prepared using a 745-W Torrey M-22R (Ciudad de México, México) meat grinder, dried for 24 h, and cut to a size adequate for consumption by Nile tilapia (4.00 mm). The proximal analyses of the diets were conducted following standard methodologies [10].

Table 1. Composition and Nutrient Levels of Experimental Diets (% Dry Weight).

Ingredients (g)	**Control**	**T1**	**T2**
Fish meal	28.0	19.6	11.2
Extruded cull-chickpea meal	0.0	30.0	60.0
Wheat meal	47.9	26.3	4.7
Soybean paste	12.0	12.0	12.0
Binder (Grenetine)	4.0	4.0	4.0
Fish oil	8.0	8.0	8.0
Vitamin and mineral mix	0.1	0.1	0.1

Proximate analysis*			
Moisture (%)	7.64 ± 0.03	7.56 ± 0.14	7.08 ± 0.01
Protein (%)	35.95 ± 0.44	32.95 ± 0.03	31.10 ± 0.40
Ether extract (%)	10.74 ± 0.01	10.64 ± 0.04	10.97 ± 0.05
Fibre (%)	1.19 ± 0.08	1.27 ± 0.34	1.75 ± 0.08
Ash (%)	5.54 ± 0.03	4.97 ± 0.02	4.83 ± 0.06
Nitrogen-free extract (%)	46.58	50.16	51.35
Energy (cal/g)	390.55	391.67	390.94

T1: 30% of cull-chickpea meal dietary inclusion, T2: 60% of cull-chickpea meal dietary inclusion. *Values are expressed as mean ± standard error (n = 3).

The mean initial weight of the Nile tilapia was 54.3 ± 0.8 g. The fish were manually fed twice a day at a feed rate of 3% of biomass per day. The total duration of the bioassay was 70 days and 100% survival was obtained in all experimental diets. Biometrics (weight and total length) were recorded every two weeks to determine: weight gain (WG = final weight - initial weight), mean final weight (MFW = final weight of total organisms/total number of organisms), absolute growth rate (AGR = [final weight-initial weight]/time), specific growth rate (SGR = 100*[Ln final weight/Ln initial weight]/time), feed conversion factor (FCR = feed supplied/weight gained), and condition factor (K = 100*[total weight/ (total length)^3]). The differences in the productive parameters between treatments were determined by analysis of variance (Kruskal-Wallis, $p < 0.05$), and the Mann-Whitney U test was used to classify the treatments.

3. RESULTS AND DISCUSSION

Tilapias fed with the control and T1 diets obtained similar values for final weight, WG, AGR, SGR and FCR (Table 2); in contrast, results for the T2 group were significantly smaller ($p < 0.05$). The K values showed significant differences between all diets ($p < 0.05$); the T1 diet displayed the highest condition factor (Table 2, $p < 0.05$).

Our results coincide with the conclusion given by Reference [11], who found that the dietary inclusion of extruded soybean meal in the diet of *O. niloticus* should not exceed 30% to avoid delaying or limiting the fish growth. In this study, the inclusion of 30% cull-chickpea meal produced similar results to those obtained with the control diet; however, an increase in the inclusion of this ingredient causes a decrease in tilapia growth. The above could be partially explained by factors such as the decrease in palatability [12], the presence of antinutrients [13], and a possible deficiency in the sulfur amino acids in chickpeas, such as methionine, cysteine, and tryptophan [14], which are found in fishmeal and required for adequate fish development [15].

Table 2. Growth performance of Oreochromis niloticus juveniles fed for 70 days with different dietary inclusion levels of cull-chickpea meal.

	Control	**T1**	**T2**
Initial weight (g)	53.61 ± 0.80 ^{a}	54.26 ± 0.81 ^{a}	54.95 ± 0.77 ^{a}
Final weight (g)	252.62 ± 7.42 ^{a}	238.36 ± 7.61 ^{a}	177.53 ± 5.70 ^{b}
WG (g)	199.01 ± 7.20 ^{a}	184.10 ± 7.32 ^{a}	122.58 ± 5.61 ^{b}
AGR (g/d)	2.84 ± 0.10 ^{a}	2.63 ± 0.10 ^{a}	1.75 ± 0.08 ^{b}

SGR (%/d)	2.20 ± 0.04 [a]	2.09 ± 0.04 [a]	1.65 ± 0.05 [b]
FCR	1.23 ± 0.05 [a]	1.27 ± 0.06 [a]	1.84 ± 0.10 [b]
K	2.00 ± 0.03 [b]	2.10 ± 0.03 [a]	1.88 ± 0.03 [c]

Results are expressed as mean ± standard error. ab Different letters represent statistically significant differences between treatments ($p < 0.05$). T1: 30% of cull-chickpea meal dietary inclusion, T2: 60% of cull-chickpea meal dietary inclusion. WG: weight gain, AGR: absolute growth rate, SGR: specific growth rate, FCR: feed conversion ratio, K: condition factor.

The results of the SGR (2.20 and 2.10) in this study were higher than those reported by other authors for *O. niloticus* fed traditional diets with fishmeal ([16], [17]). The rest of the productive parameters was within the range reported in other growth studies with *O. niloticus* ([12], [16], [17]). Preliminarily, the results of this study suggest that the dietary inclusion of 30% cull-chickpea meal could be a suitable option for the culture of this species. Other studies ([4], [8], [9], [11], [12]) confirm the use of other legumes as excellent options to reduce the use of fishmeal in aquafeeds. Likewise, the values obtained for the condition factor (K) allow us to conclude that the inclusion of cull-chickpea meal did not generate detrimental effects on the growth of *O. niloticus*. According to Reference [18], the K for juvenile *O. niloticus* fluctuates between 2.08 and 2.5; thus, it can be concluded that the fish fed the 30% inclusion of cull-chickpea diet presented the best condition. This study is the first to establish that extruded cull- chickpea meal is an adequate alternative for feeding *O. niloticus*. The results of this work allow us to conclude that diets with up to 30% inclusion of cull-chickpea meal did not produce negative effects on the growth performance of *O. niloticus*. The above, in addition to being an advantage for the area of aquaculture nutrition, is an excellent opportunity for chickpea producers, providing a new option to market the cull-chickpea that is not suitable for human consumption. However, further research is needed to evaluate the inclusion above and below 30% of cull-chickpea meal in *O. niloticus* to optimize diet use efficiency.

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